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# Fit for purpose? Sustainability and the design studio

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**Abstract:** The design studio is the primary means of educating architects. Since its emergence over a century ago, the pedagogy of the design studio has remained remarkably consistent despite changing demands placed upon the built environment. Preparing architects for the global challenge of sustainable design must be of primary importance to educators and requires critical and deep learning due to its holistic and interdisciplinary nature. The design studio seems the ideal environment for encouraging deep learning for sustainability through its potential to foster independent and deep learning. Despite this, sustainability is often viewed as additional, optional or even neglected entirely. The study examines a RIBA Part 2 design studio architecture course in the UK and considers whether the design studio pedagogy is fit for purpose in the context of contemporary architectural challenges. Conducted over two years, sampling two consecutive cohorts of students, the research adopts an ethnographic approach to reveal the structural and pedagogic issues that inhibit sustainable design. The findings suggest that the design studio, in its current incarnation, is not fit for the purpose of training practitioners to effectively engage with sustainability. Its introverted focus has led to a self-referential environment in which good design is defined by a “hidden agenda”. A lack of effective interdisciplinary working, limited pool of teaching staff and an absence of meaningful exposure to attitudes beyond the profession are all contributing factors. As a result, sustainability is not viewed as synonymous with design quality, but additional to it.

**Keywords:** Sustainable architecture, design studio, sustainable pedagogy.

## Introduction

In architectural education, in the UK and internationally, the design studio is the dominant pedagogic model. In a detailed study of 59 international schools of architecture conducted by Altomonte, Attia, Herde, and Dartevelle (2010), the design studio, or versions of the design studio (such as design “laboratories”), is common in all countries and nearly all courses considered. It forms the central part of most courses, often carrying the majority of assessment credits.

Faced with contemporary challenges of environmental degradation, economic instability and social integration, it is imperative that architects are adequately equipped to meet these issues. Accordingly, the design studio, and its associated pedagogy, must enable meaningful learning for sustainable design. The design studio can increase critical engagement and awareness, encouraging acceptance that sustainability is a contestable and value led concept (Gürel, 2010). The design studio also has the potential to encourage transdisciplinary learning (Khan, Vandevyvere, & Allacker, 2013). However, these opportunities are rarely exploited by educators however student engagement in sustainable themes is often poor (Clune, 2014).

Current incarnations of the architectural design studio can be traced back to both the Ecole des Beaux Arts in Paris in the 19<sup>th</sup> Century as well as the Bauhaus (D. Schön, A., 1985) yet its roots reside far deeper in the mediaeval guilds and the master and apprentice model of arts and crafts education (Broadbent, 1995; Lackney, 1999). The design studio is characterised by the absence of a single body knowledge which allows individuals to develop their own work in relation to a broad and eclectic professional community (McClean, 2009).

This gives rise to a complex epistemology, in which the designer's personal ideas allow an infinite number of possible design options (Shaffer, 2003).

This paper challenges the assumption that the design studio is fit for the purpose of educating architects to meet the demands of sustainable design. It understands sustainability as a pluralist concept (Guy & Moore, 2007) that is open to multiple simultaneous interpretations and requires deep and critical engagement. Given its historical roots, complex pedagogy, and its focus in independent learning, is the design studio still fit for purpose?

### **Learning for sustainable design**

The development of independent critical thought is at the heart of both studio education (McClean, 2009) and engagement with environmental sustainability built environment HE (EDUCATE, 2012). *Deep learning* describes a level of information processing that emphasises a holistic approach which focussing on underlying meaning (Marton & Säljö, 1976). This stands in contrast to surface learning and strategic learning which emphasise descriptions and competitiveness respectively (Warburton, 2003). Deep learning is particularly relevant to educating for sustainability due to its interdisciplinary, interconnected and holistic nature (Buckingham-Hatfield & Evans, 1996). Above all, deep learning must be internally motivated and the learner must have a desire to understand (Warburton, 2003). Accordingly, this requires student centred pedagogies to take prominence and reflective educators to enable this (Clune, 2014).

Deep learning implies a critical approach to understanding whereby assumed beliefs are challenged and reconsidered. It is a meta-reflective process, where the deliberate act of questioning action provides a deeper understanding. In the wider literature on learning, this process is variously described as *reflection-on-action* (D. A. Schön, 1984), *double loop learning* (Argyris & Schon, 1974) and *experiential learning* (Kolb & Goldman, 1973). It is an act of critical thinking which requires the processes of '*identifying assumptions, researching them, and generating multiple perspectives*' (Brookfield, 1997, p.25).

The nature of learning that takes place in the design studio was largely undeveloped until the work of Donald Schön in the 1980s. His book *The Design Studio* (1985) built on work in *The Reflective Practitioner* (1984) and describes a number of key concepts at play in the design studio. *Reflection-in-action* describes how professionals conduct the process of design through a constant reflective dialogue during the act of creation. In contrast, *reflection-on-action* occurs after the event and allows space for the practitioner to consider their output. Through experience of the iterative process of design, students, absorb knowledge unconsciously which becomes tacit.

Schön's reflective practice evolved from double and single loop learning (Argyris & Schon, 1974). They are distinct strategies that share commonalities with reflection in and on action. Single loop learning describes a problem solving approach whereby individuals attempting to understand internal systems in which they operate. It is concerned with improving actions to reach desired outcomes Double loop learning, by contrast, involves questioning assumptions and why action is undertaken in order to improve their inner values (Gribbin, Aftab, Young, & Park). As in deep learning, double loop learning represents a search for underlying meaning which questions both how something is done but also why it is done in that way (figure 1).

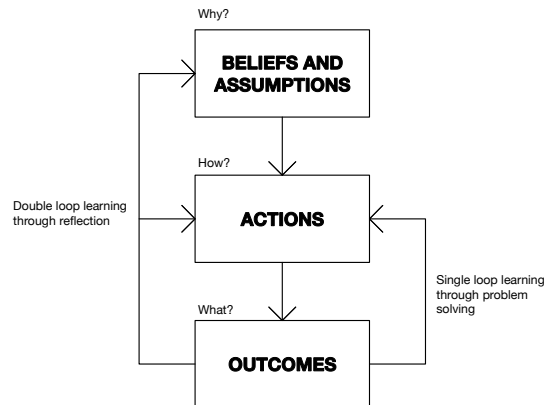


Fig 1: Single and double loop learning cycles (redrafted from Gribbin et al. )

In Schön's description of design pedagogy, Eraut (1994) suggests the designer is himself accepting the wide range of perspectives and possibilities as he tacitly explores the design process yet the transmission of this knowledge is purely didactic. The suggestion to the student is that architectural education is purely about the transmission of skills, abilities and professional competence rather than accepting it is a contested and dynamic field (Webster, 2008) undermining the potential for deep learning for sustainability. Schön also fails to note the importance of immersion in architecture, and limits his description of learning to formal encounters between master and student. Webster (2008) suggests informal learning is essential to architectural education and that high performing students engaged in '*reading expansively, visiting cities, buildings and exhibitions, attending lectures, spending long hours in studio, and living in houses with other architectural students.*' (p. 67), characteristics consistent with a deep learning approach.

### Challenges in the design studio

The studio appears an ideal environment for developing deep learning (Clune, 2014) for sustainability. It encourages independence, reflective analysis and critical thinking. Banerjee and Graaff (1996) assert, however, that relying on the design studio to develop a particular set of values and skills may be unreliable. Furthermore, self-directed learning may negatively impact student time and direct it away from other aspects of the curriculum (Datta, 2007). Similar observations were made by Oliveira and Marco (2016) who saw that student directed briefs often neglected sustainability. Misconceptions regarding sustainability can lead to barriers to implementation (Filho, 2000) and presenting sustainability as a vague and pluralist concept confounds this (Gürel, 2010).

Cotgrave and Alkhaddar (2006) have pointed out that there is a need for learning outcomes and module design to reflect issues in sustainability however current courses are often designed around course inputs such as resources and staff expertise. Integration must be holistic and coherent as fragmentation, ad-hoc additions and non-uniformity may prevent meaningful integration (Cotgrave & Alkhaddar, 2006).

The development of the design studio leaves one questioning the alignment between its pedagogy and intended outcomes. The master-apprentice model, on which the studio was founded, poses particular problems for developing deep sustainability. The challenges of sustainability require innovative approaches, picking apart widely held assumptions, and considering alternative ways of acting. Dutton (1987) points towards a powerful hidden

agenda of the studio that both intentionally and subconsciously the it acts to legitimise certain types of knowledge and practice. Underpinned by hierarchical social structures and unchallenged assumptions, each design studio or school of architecture delivers a particular form of architectural and professional agenda (Dutton, 1991). This professional validation, generated by institutionalised power asymmetries, necessarily excludes alternative forms of practice and in turn, validates the profession and promotes '*a series of self-referential and autonomous values*' (Till, 2003). In the search for innovative processes, underlying meaning and challenging assumptions, '*thinking like an architect*' (Weaver, 1997) may prove problematic. Stevens (1995) notes the tendency of architectural education to '*favour the favoured*' that is to preserve the status quo of the profession limiting its social diversity. Placed in the context deep learning, this limits the exposure of students to multiple points of view, reinforcing professional assumptions and behaviours undermining critical understanding (Brookfield, 1997).

Perhaps the biggest barrier to learning for sustainable design in the education of architects comes from the professional and institutional culture it operates within. Murray and Cotgrave (2007) suggests that despite the minimal requirements of sustainability in the curriculum laid down by professional bodies, the major hurdle to overcome is a professional one. Alabaster and Blair (1996) note that academics in HE are often resistant to values imposed from outside their subject areas. This poses a particular problem to the interdisciplinary nature of environmental sustainability.

### **Context of the case study**

Learning in the studio at the case study university is focussed around design projects, developed both for and by students. The design project is the vehicle for learning; the design studio provides its context. While deep and experiential learning may underpin the epistemological motivations of the studio these cognitive processes are framed through the process of design itself which has its own codes and conventions. At the case study university, the critical method (CM) is explicitly advocated as a model of design. CM is passed on the critical rationalism of Popper (1963) and was applied to design initially by Darke (1979) and developed by Brawne (2003). It describes a process of conjecture followed by analysis or, in the terminology of Brawne (2003), *tentative theory* followed by *error elimination*. CM is an iterative process of informed guess work (Bamford, 2002) tested through the application of professional tools (drawing, modelling etc.). Darke (1979) proposed a further aspect to the cycle: the *primary generator*. A primary generator, also termed the design concept, describes the initial starting point of the process based on the designer's preconceptions, experiences and personal motivations. It is most often an *article of faith*, a collection of conceptual ideas, rather than a rational list of constraints (Darke, 1979).

In the context of deep learning for sustainability, the reflective cycle runs parallel to CM: initial assumptions constitute primary generators; action generates conjectures; and design solutions provide experiences. Accordingly, in order for effective deep learning for sustainability to take place, it is not enough for the design cycle to consist of only conjecture and analysis generating new conjecture, as suggested by (Brawne, 2003). Instead, the designer must constantly return to their primary generators, questioning their initial underlying assumptions in light of newly created design knowledge.

The field of study was a final year MArch design studio at the case study university. This allowed participants to have a reflective view on their architectural education and were most likely to go into architectural practice, maximising potential impact of the research. The

MARch course is organised through a single studio in which all students undertake a self-defined project in a European city of their choice. The first half of the year is organised into groups, each of which undertake a master-planning project. The second half is an individual project in the chosen city with a brief defined by the student. Studio tutors support the students and in the second half of the year each student is assigned a tutor to guide them through the project. The participants had a sophisticated level of design ability and could articulate values and understand issues.

## Method

The research was conducted in situ and results are contextual, value-bound and consist of various overlapping realities which generated *working hypotheses*, rather than concrete theory. It is purposive, and sampled an individual context and responded to the particular characteristics of the population (Lincoln & Guba, 1985). The research utilised a qualitative approach using direct (rather than remote and inferential) methods to capture individual points of view and the messiness of everyday life. The findings are embedded within this context. The paper uses a “rich” description to provide detailed accounts of the study (Denzin & Lincoln, 2011).

The research took place over a two-year period. An ethnographic study was undertaken to identify issues and possible domains for change. The participants in the study were final year MARch (RIBA 2) students at the study university. The participants were typically in their sixth year of formal architectural education. The researcher was a member of staff at the case study department but not directly involved in teaching on the MARch course in order to avoid possible bias. The role of the researcher was predominantly one of *observer-as-participant* (Gold, 1958). In this role most data were gathered through relatively formal settings, (scheduled interviews and planned observations) in which the researcher was considered ‘*acceptable incompetent*’ (Lofland, 1971). In all cases the participants were aware of the presence and role of the observer. The researcher’s role allowed a passive approach that limited impact on the students. The openness of the study and knowledge of participants negated the potential ethical implications of a more immersive researcher role. It allowed a broader data set to be gathered, maintained a suitable distance from the subjects and avoided possible ethical issues. Consideration was also given to discretion in interviews, responsibilities to student welfare, preferential treatment and respecting the attitudes of student to remain anonymous.

Data collection involved a cyclical process of collection, analysis and validation which informed further cycles (Cohen, Manion, & Morrison, 2000). A voluntary sample of 20 participants within the population (n=70) were interviewed using semi-structured interviews (Patton, 1980). This provided a baseline understanding and informed further data collection and analysis. 4 educators on the course provided supplementary interviews. Observations of crits and tutorials were undertaken by the researcher in a *naturalistic* manner (Lincoln & Guba, 1985). These provided a formal educational encounter which gave data on the students and educators. Observations were noted and categorised in-situ paying particular attention to the theming of discussions taking place as well as the nature of this dialogue.

Analysis of the data occurred in tandem with collection allowing a continuous process of verification and theory generation (Cohen et al., 2000). On a practical level, the researcher could deal with a large quantity of data and sufficiently narrow the field of inquiry in later study. The data were analysed in a seven step process in which data were unitised (coded), clustered into domains, relationships established, inferences made, summarised, negative

cases sought and theory generated (Cohen et al., 2000). NVivo, software which supports qualitative research, was used to analyse and code the data. Writing the report is an important aspect of the naturalistic research process, and accurate representation of the research situation is essential to achieving trustworthiness (Lincoln & Guba, 1985). It is essential that the report *catch and portray* to the reader what it is like to be embedded in the specific case study (Cohen et al., 2000). In line with the guidelines set out by Lincoln and Guba (1985) the report writing focussed on the presentation of facts linked to the collected data, anonymised participants and began by over-including data which was then edited (p.365-6). The report writing process occurred in a cycle with the data analysis, allowing categorisation of data, and informed recoding and restructuring of the data.

## **Results**

### ***Curriculum and structure***

The curriculum set for the design studio at the case study university consists of a series of assignments, assessed against set criteria known as Independent Learning Outcomes (ILOs). The ILOs were drawn directly from the graduate requirements of the ARB and RIBA (Architects' Registration Board, 2010; Royal Institute of British Architects, 2010) of which four deal with environment and sustainability. At the case study university these ILOs are removed from the design studio and covered in a separate unit taught in the first year of study in order to allow relative “freedom” in the design studio. The unit convenor for the design studio described the ILOs as the “*point of failure*” for the unit.

Sustainability was covered in the general briefing document for the studio assignment, in which, as one staff member put it:

*“...there is an explicit paragraph about sustainability issues and they should be explicitly addressed, but the response to that given the nature of the buildings and the locations is by definition broadly trying to make a catchall statement.” (Michael, tutor)*

One student described the impact of this explicit description in the brief:

*“...it becomes our design agenda ... we are creating a sustainable city. It's in the name so you're almost forced to do it.” (Georgina)*

While raising consciousness, this explicit framing also placed sustainable design as an isolated topic, separate from more conventional architectural approaches.

A number of additional lectures and satellite modules that ran parallel to the studio. In the case study MArch studio, the participants had undertaken a 10 week lecture course on sustainability and environmental design in the first year of study. Despite being unrelated to the design studio, the lectures were considered valuable by students as providing “core” knowledge. The course administrator also spoke of the need for sequential learning to adequately integrate sustainable design holistically into design projects. Despite the perceived necessity for lectures to supplement studio work, there was little evidence of the taught content from lectures manifesting itself in design projects. Sustainable strategies were specific to projects and individually researched. One student highlighted the abstraction of lectures and its seeming irrelevance to design studio work while another described the “disconnect” between learning in lectures and the studio:

*“There is a disconnect between what you learn in lectures and what you actually do in the studio. I don't think I used anything that I learnt in lectures to what I do in my design studios.” (Simon).*

### ***Studio pedagogy***

The design studio at the case study university underpins the curriculum at the case study university. Assessment of the design studio through completed project work forms 70% of the final degree classification. Accordingly, this is based on the assumption that the design process itself is an educational one. Students were able to integrate sustainable concerns throughout their projects, from initial ideas to detailed designs.

*"for example on the site, where we put the building on that site and that is one of the first considerations of the environmental strategy...then later on you can consider the environmental strategy again as to what sort of technology you can put in your building to make it more sustainable."* (Simon)

The application of sustainable principles through to design projects was a clear concern among students however it was typically seen as a series of additive measures that could be overlaid onto completed designs. Learning was often restricted to technical knowledge about particular systems and lacked *"meta-knowledge"* and holistic thinking. Students spoke of it being *"put on at the end [of a project]"* (Laura), *"applied"* to the project (Chris) or in some cases viewed as optional or impossible:

*"I'm not sure whether it's realistic that you do consider the environmental aspect of every project."* (Simon)

There was an explicit attempt by educators to get students at MArch level to adopt holistic and *"whole-system"* approaches. They spoke of students' varying levels of engagement with sustainability in their design projects however noted a lack of a fundamental integration.

*"I've never been led by a student into discussing their design thinking, in what I would describe in the broadest definition of sustainable ideas."* (Michael, tutor)

Adopting design as an educational process placed emphasis on a practical, problem-solving approach to sustainability as well as generalised, non-specific strategies. This tended to manifest itself in technical *solutions* to issues which demonstrated integration but undermined more holistic approaches. According to one educator, this was exacerbated by the experience of tutors, who mostly consisted of practitioners. The nature of the design project as a medium for learning tended to undermine rigorous and in-depth analysis. A number of students expressed a desire for quantitative processes:

*"In the design studio it's hard. For me sustainability comes out in the excel spreadsheet really. You can sort of convince in the design studio but really it's hard to quantify."* (Phil)

Others felt the lack of genuine analysis could mask basic or ill-conceived approaches:

*"if you want to avoid it you can avoid it easily"* (Anne)

The design studio was characterised by individual freedom and independent learning. Students were able to choose their own design projects and explore themes important to them. This enabled some students to explore overtly environmental agendas (such as a research centre for climate adaptation) and develop knowledge beyond that of their tutors. For others, this freedom allowed them to all but avoid environmental concerns:

*"This is seen as your opportunity to be free in design and be as creative as you can and if you perceive that as something that hinders creativity or is it another thing that gives you constraints that may help you design something better."* (Jane)

The lack of sustainability focus was in part due to the complexity of a design project. One tutor described it as a *"complex Venn diagram"* with sustainability occupying one small section. This open-ended complexity requires students to construct their approach based on prior interests, values and assumptions.

### **Agenda and values**



The design studio was observed to embody implicit values which had considerable impact on design for sustainability. There was clear value placed on the design process as iterative, involving trial and error and the disposal of physical artefacts, rarely recycled. One tutor described the environment of the design studio to *“tend not to look like the sort of places where people are concerned with materials. The material is visibly wasted and treated quite badly and not valued.”* (Michael, tutor)

Students and tutors both described a set of underlying “agendas” for design which were perceived as conflicting with, or undermining, sustainability. One student expressed this tension as the difference between something being *“design led”* and sustainable (Martha) while another described it as the balance between aesthetics and sustainability (Jane). This dichotomy was echoed by tutors; one spoke of the students who designed with an *“architectural aesthetic and visual approach”* in which sustainable concerns were secondary (Alan, sustainability tutor) while another described other more practical design concerns (such as the location of the front door or the sizes of the rooms) taking precedence (Michael, tutor).

Sustainable design was often seen as uninteresting to students and not appreciated by critics or tutors. In most cases it was seen as additional to the primary agenda to the project, something that might be added on at the end:

*“I find students who really have impressive environmental strategies do that in a modest way that isn’t necessarily celebrated through the projects and it’s students who do crazy processes of their building type which is far more interesting.”* (Martha).

The overarching explicit agenda of the department had a mixed impact on students. While tutors suggested that the department focussed on sustainability more than at other schools of architecture, student perception varied, based on comparisons with prior educational experience. Despite a strong sustainable research agenda in the department, little of this filtered into the design with most researchers having no connection to the course. Tutors were either full time teaching staff (non-research) or external practitioners who taught part-time.

Students’ own experiences had a strong impact on their approach to sustainable design. Study visits such as trips to buildings and cities were key for raising awareness of sustainable issues. Despite all students having between 1 and 3 years of professional practice experience, few spoke of this time as being particularly influential on their outlook. A number of students demonstrated strong personal motivation. For example, three of the students had undertaken Passivhaus courses in their own time while another had been to a sustainability conference. Many demonstrated personal motivation and aspired to sustainable lifestyles however did not translate these values into the design studio, a view echoed by staff.

*“...[I am sustainable] more outside of architecture...so things like in my household we’re quite keen on measuring energy usage and involved in community projects, that kind of stuff.”* (Martha)

*“...they [students] talk a good game but in reality they don’t act a good game.”* (Michael, tutor)

### **Teaching interactions**

Formal student and tutor interactions in the design studio primarily took place in two different teaching events; tutorials and crits. Tutorials describe an in studio session normally involving a single student and tutor (on group projects this was a group and one or two tutors). Crits were formal presentations in which students pinned their work on the walls and

presented them in front of a panel of “critics” (normally comprising of tutors and invited external experts).

Tutors saw their roles in different ways. The sustainability tutor (Alan) saw himself as *“a facilitator and someone who gives strategies and techniques to employ”* operating as an expert consultant. Conversely, Michael (tutor and tutor) viewed tutoring as *“purposefully avoiding closing things down and avoiding solving problems for them and proactively try to listen a lot and talk less and try and get them to say what they were thinking more”*. From observed tutorials, while these different styles were apparent, the tendency to proffer design ideas was prevalent. Of the six tutors observed or interviewed, those who were thought of in a technical capacity (such as Alan) identified problems and offered “solutions”, continuously drawing and working through the design. By contrast, other tutors relied almost entirely on verbal communication however were still observed to raise issues and describe potential solutions.

In all cases, tutors were influential on the work of the students. Students described how specific design ideas had originated from their tutor, or how a particular tutor had directed them to explore a particular theme. This influence could encourage a student to place sustainable design at the heart of their work. In other cases, students felt their tutor was not interested in sustainable design or *“didn’t real necessarily talk about it”* (Yvonne).

Crits were predominantly student led; students chose what work to present which in turn directed the nature of the conversation. For example, in one observed crit, one of fifteen discussion topics were focussed on sustainability, and in another, only three of twenty. By contrast, in one scheme where the students had developed a particular strong sustainable agenda, eight of the twelve discussion points centred around sustainability concerns. As well as the content of the crit, its format (45 minutes long analysing work pinned up on a wall) led to graphical and verbal presentations which favoured clarity and brevity at the expense of rigour and ambiguity. Students felt the need to produce *“flashy”* images, while others noted the inadequacy of the crit to showcase technical design.

## Discussion

The design studio represents a complex and multi-faceted learning environment in which the simple addition of sustainable design content has limited effect, supporting the assertions of Warburton (2003). While the need for RIBA and ARB compliance ensures curricula address sustainability concerns, the possibility to extricate these ILOs into satellite units, unrelated to the design studio avoids the need for integration. Moreover, the consideration of learning outcomes as the *“point of failure”* of a unit relegates them to the level of compliance. Integration is far more successful when it is made the *“theme”* of the design studio and is overtly described in assignment briefs. This points to a fundamental misalignment between learning outcomes and design expectations.

The foci of the design studio are governed by underlying values that determine good design. This *“hidden agenda”* (Dutton, 1987) describes a self-validating approach to architectural design in which students, staff and practitioners define primary architectural concerns through the development of a tacit, internalised language. Sustainable design is often seen to be at odds with *design*; students spoke of the need to balance these two competing concerns. While the literature on sustainable design advocates interdisciplinary working that draws from a range of different backgrounds (Jones, Selby, & Sterling, 2010) the design studio is taught by practitioners of architecture who themselves were educated in the same system. This generates an echo-chamber in which external influences are limited and

alternative perspectives denied. This has led to an internalised validation system that fails to address challenges beyond the assumed scope of architecture.

Educator and student interactions limited the possibility for sustainable design. With the exception of one tutor who adopted a highly theorised, psychoanalytical approach, tutors rarely critically questioned assumptions, but rather engaged in mimetic processes such as drawing ideas or verbally describing possibilities. Questioning students was normally to clarify points. This reflects Schön's (1985) description of architectural teaching in which the tutor demonstrates *reflection-in-action*. In the context of education for sustainable design however, this was seen to limit deep learning. Not only was the learning restricted to the absolute knowledge of the tutor, but the teaching failed to address the holistic, interdisciplinary and critical approach required for deep learning (Buckingham-Hatfield & Evans, 1996). In crits there was an emphasis on presentation and product to aid communicative clarity. For some students, this either undermined or removed the need for procedural rigour. Crits were student-led and discussions surrounding sustainability relied on the nature of the work presented. This corroborates the work of Datta (2007) and Oliveira and Marco (2016) who suggest self-directed learning can exclude sustainability concerns. A lack of engagement in sustainability was partly blamed on the perceived attitudes of critics and tutors, whom many students considered not to value it, reinforcing accepted institutional and professional practices.

The pedagogy of the MArch studio served to develop *reflection-in-action* (D. Schön, A., 1985), the ability to think like an architect, yet this was confined by a narrow frame of reference. This limited the ability to address sustainable issues, challenge assumptions and create a wide variety of innovative proposals, and prevented genuine deep learning for sustainability. Nevertheless, the studio provided space for individual engagement with the four stages of Kolb's learning cycle through individual project led learning (Kolb, 1984), however concrete experiences and abstract conceptualisation was restricted to a narrow sphere of knowledge. The MArch studio provided the illusion of independence but student process and learning were both consciously bound (through the requirements of assignments) and subliminally influenced (through exposure to a limited range of experiences and perspectives) by the context of study (Ward, 1990). Ultimately the design studio was seen to be a single loop learning environment (Argyris & Schon, 1974) in which basic assumptions were rarely challenged.

The challenges of the design studio to adequately adapt a sustainable future may be attributed to the nature of the design-problems that the studio has evolved to deal with. The focus of the design studio on generating well-formed "solutions" emphasises production over process and learning. Not only is sustainability "wicked" in nature (Rittel & Webber, 1973), but it also relies on holistic, collaborative, interdisciplinary and critical learning (Howlett, Ferreira, & Blomfield, 2016). The autonomous problem-solving approach of the design studio, disciplinary focus and dependence on professional competence is inadequate for educating to meet the challenges of sustainability.

## Conclusion

In order to successfully transform the design studio to engage with the challenges of sustainable design, it is not enough to merely add content or demand compliance. In the case-study, the structure, agenda and pedagogy acted as the primary barriers to successful integration. To educate for sustainable design, the findings suggest the design studio must embrace alternative perspectives and interdisciplinary working. Educators must be drawn

from a variety of fields with a diverse range of backgrounds in order to break the introverted cycle of design validation. Theming design studios around sustainable design which can encourage early integration and the creation of sustainable narratives. The emphasis on design product, prevalent in the case-study, should be shifted to process which embraces holistic design approaches that challenge conventional understanding of sustainable design. Deep learning must be facilitated through the creation of an environment which constantly questions underlying assumptions and values a plurality of design approaches. Exposing students to a variety of external experiences may also raise critical awareness and engender intrinsic motivation for sustainable design. Ultimately, the specific pedagogy of the studio is drawn into question. Developing independent learners in an apprentice-style environment limits the holistic and critical thinking required for sustainable design.

This study has implications for both educators and professional bodies. Educators must rethink how the pedagogy of the design studio may be evolved to address sustainable design. The ARB and the RIBA must reconsider the role of required graduate attributes and how these impact design teaching. Further work might expand this study to other schools of architecture to validate these findings and assess its transferability to other contexts.

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